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Description

This invention relates to a vane controller for controlling a plurality of vanes disposed in a fluid conduit and more particularly, but not exclusively, to a vane controller for driving a set of vanes which effect capacity control in a fluid machine such as a turbo-compressor having a vane wheel, e.g. an axial or radial flow vane wheel.

A conventional vane control apparatus is disclosed, for example, in Japanese Patent Publication JP-B-57-49759. This apparatus will be explained with reference to accompanying Figures 9 to 11, which show a vane wheel 1 of a centrifugal compressor and a casing 2 for the flow control vanes and the vane controller attached to a suction bell mouth 2a. A plurality of vanes 3 are mounted upstream of the vane wheel 1. One of these vanes 3 is a driving vane 3a. The outer end portions of these vanes 3, 3a are supported rotatably by vane shafts 4, 4a carried by ball bearings 5 disposed in the casing 2. A driving arm 6 is fixed to the driving vane shaft 4a and a connecting rod 7 has one end fitted to the driving arm 6 by a pin 8 and the other end fitted to an actuator 9. The driving vane shaft 4a is rotated by the operation of the actuator 9.

A driving control lever 10 is fitted at one end to the driving vane shaft 4a and the other end of this lever 10 is connected to a control ring 11, which is arranged to rotate slidably around the outer periphery of the casing 2 adjacent to the vane shafts 4, 4a, through a linkage 12 composed of two universal joints. Since each vane shaft 4 is connected to this control ring 11 through a follower control arm 14 with a similar linkage 13, all the vane shafts 4 are rotated in synchronism with the driving vane shaft 4a through the control ring 11 when the driving vane shaft 4a is rotated by the operation of the actuator 9. Thus the degree of opening of the vanes is selected.

The problem with this conventional vane control mechanism is as follows. Since the control ring 11 moves round the surface of the casing 2, frictional resistance is great so that the torque required of the actuator for driving all the vanes 3 becomes great. If this frictional torque can be reduced, the torque required is only the air torque acting on each vane 3, 3a and consequently, the torque necessary for moving the vanes can be reduced drastically. Large frictional resistance results in poor response of the vane opening and closing operation and is not suitable for the case where the vanes are repeatedly opened and closed. In addition, the linkage between the levers and the control ring is complicated.

Japanese Utility Model Publication JP-B-44 21729 discloses another vane control mechanism applied to rotating vanes in an axial compressor, in which a control ring in a fixed axial position moves the vane shafts through levers having spherical ends received in bearing sleeves which slide both radially and axially in apertures in the control ring. The ring is spaced from the compressor duct wall and slides at its inside face on the projecting ends of the vane shafts. In this the vane rotating lever is difficult to machine and causes a high production cost because spherical machining is necessary for the spherical bearing and the tip of the lever.

DE-A-2618727 shows another vane control mechanism in which a control ring is connected to the vanes through flexible levers which are connected to the ring by universal joints. The ring itself is carried by the vane shafts and the flexible levers.

In order to solve the problems of the prior art described above, the present invention has the object of providing a vane controller which can reduce frictional resistance of the control ring and is simple and can reduce the cost of production.

The vane controller of the present invention is set out in claim 1.

In one form of the invention, the vane shafts are attached to first ends of levers, and second ends of the levers are connected to the control ring by connections constraining said ring and the second ends to move together circumferentially, while permitting relative movement of each second end and the ring in a direction having a component parallel to the respective vane shaft axis. The control ring is movable both circumferentially and axially and the second ends of the levers are constrained by said connections to move both circumferentially and axially with the ring.

Preferably, the second end of each lever and the ring are connected by a first element and a second element, said first element being one of a pin and a bearing receiving said pin and said second element being the other of said pin and said bearing, said first element being at a fixed location on said lever and said second element being at a fixed location on said ring.

The bearing preferably has a spherical bearing member slidably and rotatably receiving the pin at its center and a housing retaining the spherical bearing member.

The control ring is spaced from the wall of the conduit. Resilient means, e.g. springs, may be arranged between the levers and the control ring, to maintain the position of the ring.

The support means acting upon the outer periphery of the control ring are suitably arranged at at least three separate and spaced locations around the ring. Preferably there are not more than six of said separate and spaced locations. Each support means may comprise a roller contacting the outer periphery of the ring.

The invention also provides a turbo-compressor having an inlet conduit, vanes in said conduit for control of inlet gas to the compressor, and a vane controller as described above for controlling the positions of said vanes.

Embodiments of the invention will now be described by way of non-limitative example with reference to the attached drawings in which:-

Figure 1 is a sectional side view of part of a vane controller for a turbo-compressor in accordance with one embodiment of the present invention;

Figure 2 is a front view onto the vanes of the vane controller, partly in section and in the direction of arrow A in Figure 1;

Figure 3 is an enlarged partial sectional view on the line B in Figure 2;

Figure 4 is an explanatory view showing the movement of the control ring of Figure 1 in the axial direction;

Figure 5 is a part sectional side view similar to Figure 1 showing the principal portions of the vane controller;

Figure 6 is a sectional view on line C-C in Figure 5;

Figure 7 is an enlarged view showing the bearing portion of Figure 6;

Figure 8 is a side view, partly cut-away, of a second vane controller embodying the present invention applied to the inlet control vanes of a turbo-compressor;

Figure 9 is a longitudinal sectional view showing the conventional vane controller already discussed;

Figure 10 is a sectional side view showing portions at the driving vane of the controller shown in Figure 9; and

Figure 11 is a sectional view taken along line I-I of Figure 10.

In the drawings of the present embodiments of the invention, like reference numerals are used to identify the same or like components as in Figure 9 showing the prior art apparatus, and will not be further described in detail.

Referring first to Figure 2, there is shown a plurality of flow control vanes 3, 3a in their fully open position inside the casing wall 2 of the inlet conduit of a turbo-compressor. Five vanes are shown. The vanes are carried by radially extending vane shafts 20, 21, which are supported by bearings in the wall 2. The longer vane shaft 20 is the driving vane shaft carrying the driving vane 3a and driven by an actuator rod 7 through a lever 6, in a similar manner as described for Figure 9. The control ring 30 of this embodiment is shown in section in Figure 2.

Each vane shaft 20, 21 is connected to the ring 30 by means of a lever 22 which is rigidly attached to the vane shaft at one end and carries a rigidly mounted pin 23 at its other end. The pins 23 extend parallel to the axes of the vane shafts 20, 21 and are connected to the ring 30 by a bearing mechanism 24, 25 described in more detail below. Figure 2 also shows helical springs 26 surrounding the pins 23 and providing an outward resilient force acting between the levers 22 and bearings 24, 25, to urge the ring 30 outwardly. This has a centering effect on the ring 30. The ring 30 is also supported by bearings 31, described in more detail below, which engage its outer periphery at three spaced apart and separate locations, as can be seen in Figure 2. Figure 2 also shows that the ring 30 is substantially spaced from the wall 2 of the conduit.

Figure 1 shows the ball bearings 5 by which the vane shafts 20, 21 are located in the conduit wall 2 and shows the ring 30 supported at its radially outer side by the bearing 31. This bearing 31, together with the connection between the pins 23 and the ring 30, allow this control ring 30 to move both circumferentially and axially with respect to the axis of the conduit 2.

Figure 3 shows a construction of the bearing 31 in more detail. A fixed rod 31 slidably carries a rolling bearing 32, which carries a roller 33 having a surface in rolling contact with the outer peripheral face of the ring 30 and flanges at its axial ends to retain the ring 30. The bearing 32 is slidable along the rigid rod 31, to permit the control ring 30 to move axially.

Figure 4 shows the principle of the axial and circumferential movement of the control ring 30 and the bearing 24 receiving the pin 23 of the lever 22 which rotates around the axis of the vane shaft 21. When the vane shaft 21 rotates by an angle of α degrees, the control ring 30 moves in the axial direction (to the right) by the distance Δx from the original position (p1) to the second position (p2). The control ring 30 also moves circumferentially, and the bearing 24, 25 constrains the pin 23 to move both axially and circumferentially with the ring 30. Since the lever 22 moves in a plane, the pin 23 must move, relative to the ring 30, in the direction parallel to the axis of the vane shaft 21. This movement, which is permitted by the construction of the bearing 24, 25 is illustrated in Figure 6, where the two positions of the pin 23 corresponding to the positions (p1) and (p2) are shown. It can be seen that the bearing 24, 25 and the pin 23 have moved relatively by a distance Δh. In effect the pin slides through the bearing, and the amount of such sliding is sufficient to allow the desired degree of control of the vanes.

The construction of the bearing 24, 25 is shown in detail in Figure 7. The bearing consists of a sleeve 24a forming a plain bearing slidably receiving the pin 23. Thus the pin 23 can move

axially with respect to the sleeve 24a and can also rotate in the sleeve 24a. The sleeve 24a is fixedly mounted, by press fitting, in a central aperture in a spherical bearing member 24, which is itself rotatable spherically, i.e. about two mutually perpendicular axes, inside a housing 25 which has a surface corresponding to the spherical outer surface of the bearing member 24. The housing 25 is fixed in the ring 30.

The pin 23 is as mentioned fixed in position on the lever 22. The bearing arrangement shown in Figure 7 is itself fixed in its location in the ring 30, but permits the pin 23 to tilt relative to the ring 30 in the plane of the ring 30, by movement of the bearing member 24 in the housing 25. This tilting movement is required in order that the pin 23 shall remain parallel to the axis of the vane shaft 21, as the ring 30 rotates circumferentially around the conduit. Additionally the pin 23 is able to move, relative to the ring 30, in the direction of the axis of the vane shaft 21, by sliding along the sleeve 24a.

Although the spherical bearing member 24 allows tilting of the sleeve 24a about two mutually perpendicular axes, it is in fact only necessary that the pin 23 can tilt relative to the ring 30 in the plane of the ring.

Both the plain bearing sleeve 24a and the spherical bearing 24 in its housing 25 are standard, commercially available items, which are assembled as shown in Figure 7 to provide the special bearing used in this embodiment of the invention..

All the levers 22, pins 23 and bearing 24, 25 are identical, around the ring 30. An actuator 9 for the vane controller of Figures 1 to 7 is of a conventional kind and corresponds to the actuator 9 of Figure 10. Operation of the actuator 9 causes the rotation of the driving vane shaft 20 which in turn drives the ring 30 circumferentially. The ring 30 is then constrained to move axially as well as circumferentially by the pins 23, and in turn rotates all of the vane shafts 21 to adjust all of the vanes in unison.

Although the control ring 30 as shown in this embodiment is supported by the guide member 31 which incorporates a rolling bearing, alternatively a plain bearing may be used, which permits the axial movement of the control ring 30.

It will be appreciated that the mechanism of this embodiment has particularly low friction characteristics. Frictional resistance is provided only by the rolling bearings 33 and the movement of the pins 23 in the bearings 24, 25, apart from the resistance of the bearings 5 and the torque applied by the flowing air from the vanes 3. The total friction is small. The mechanism is also simple to produce and therefore economic in production. It undergoes little wear during operation, and thus provides accurate control of the vanes.

Another embodiment of the invention is shown in Figure 8, in which items corresponding to those of Figures 1 to 7 are given the same reference numerals and will not be described in detail. Figure 8 shows a radial turbine compressor wheel 1 and an inlet conduit 2 to this wheel 1. In the conduit are mounted control vanes, carried by vane shafts 21 projecting through the wall 2. Through levers 22, and pins 23 and bearings 24, 25 as shown in Figures 1 to 7, these vane shafts 21 are controlled in unison by the control ring 30 which in this case is an annular plate, movable circumferentially and axially. This embodiment differs from that of Figures 1 to 7 in that the bearings 24, 25 are not mounted in the plate but on short rods projecting axially from the plate and secured by nuts rigidly to the plate 30 in the correct positions to receive the pins 23. Thus, as in the previous embodiment, the bearings 24, 25 are fixed in their location relative to the control ring 30. Figure 8 also shows one of the three rollers 33 engaging the outer periphery of the control ring 30 and rotatably and slidably mounted on the fixed rod 31 which is carried on the frame of the compressor by a rod 34.

It will be appreciated that the mechanism of these embodiments have particularly low friction characteristics. Frictional resistance is provided only by the rolling bearings 33 and the movement of the pins 23 in the bearings 24, 25, apart from the resistance of the bearings 5 and the torque applied by the flowing air on the vanes 3. The total friction is small. The mechanism is also simple to produce and therefore economic in production. It undergoes little wear during operation, and thus provides accurate control of the vanes.

The number of control vanes is typically eleven in a turbo-compressor, but any suitable number may be applied in other devices, to which the invention is widely applicable.

Although in the illustrated embodiments the pin 23 is shown mounted on the lever 22 and the bearing on the control ring 30, these positions may be reversed.

The minimum number of support bearings on the outer periphery of the control ring 30 is three, to achieve concentric circumferential movement. More support bearings may be used, but for simplicity of construction and adjustment a preferred maximum in practice is six.

Claims

1. A vane controller for a plurality of vanes (3,3a) disposed in a fluid conduit (2), having vane shafts (20,21) connected to the vanes and extending radially and spaced circumferentially around the conduit, a control ring (30) outside and spaced from the wall of the conduit and

movable circumferentially and connected to said vane shafts by levers (22) to cause the vane shafts to rotate in unison to adjust the vane position,

characterised in that said control ring (30) is supported by support means (31,33) acting upon its outer periphery, and said support means are fixed relative to the wall of the conduit.

2. A vane controller according to claim 1 wherein said support means (31,33) are arranged at at least three separate and spaced locations around the ring (30).

3. A vane controller according to claim 2 wherein there are not more than six of said separate and spaced locations.

4. A vane controller according to claim 2 or claim 3 wherein at each of said locations said support means comprises a roller (33) contacting the outer periphery of the ring.

5. A vane controller according to any one of claims 1 to 4 wherein said control ring is movable axially as well as circumferentially and is connected to said vane shafts by levers (22) to cause the vane shafts to rotate in unison to adjust the vane position; wherein said vane shafts are attached to first ends of said levers and second ends of said levers are connected to the control ring (30), and said second end of each lever (22) and said ring (30) are connected by a first element and a second element, said first element being one of a pin (23) and a bearing (24,25) receiving said pin and said second element being the other of said pin (23) and said bearing (24,25), said first element being at a fixed location on said lever and said second element being at a fixed location on said ring.

6. A vane controller according to claim 5 wherein said bearing has a spherical bearing member (24) slidably and rotatably receiving said pin (23) at its centre and a housing (25) retaining said spherical bearing member (24).

7. A vane controller according to any one of claims 1 to 6 including resilient means (26) arranged between said second ends of said levers (22) and said control ring (30).

8. A turbo-compressor having an inlet conduit (2), vanes (3,3a) in said conduit for control of inlet gas to the compressor, and a vane controller according to any one of claims 1 to 7 for controlling the positions of said vanes.

Patentansprüche

1. Leitschaufel-Einstelleinrichtung für mehrere in einer Fluidleitung (2) angeordnete Leitschaufeln (3, 3a), mit Leitschaufelachsen (20, 21), die mit den Leitschaufeln verbunden sind und sich radial erstrecken und in Umfangsrichtung um die Leitung voneinander beabstandet sind, einem ausserhalb der Wand der Leitung und von dieser beabstandeten Einstellring (30), der in Umfangsrichtung verstellbar ist und mit den Leitschaufelachsen über Hebel (22) verbunden ist, um dafür zu sorgen, daß sich die Leitschaufelachsen übereinstimmend verdrehen, um die Leitschaufelposition einzustellen;
dadurch gekennzeichnet, daß der Einstellring (30) von auf seinen Außenumfang wirkenden Trägereinrichtungen (31, 33) gehalten wird, die relativ zur Leitungswand feststehend sind.

2. Leitschaufel-Einstelleinrichtung nach Anspruch 1, bei der die Trägereinrichtungen (31, 33) an mindestens drei voneinander getrennten und um den Ring (30) herum beabstandeten Orten angeordnet sind.

3. Leitschaufel-Einstelleinrichtung nach Anspruch 2, bei der nicht mehr als sechs der getrennten und voneinander beabstandeten Orte vorliegen.

4. Leitschaufel-Einstelleinrichtung nach Anspruch 2 oder Anspruch 3, bei der die Trägereinrichtung an jedem der Orte eine Rolle (33) aufweist, die mit dem Außenumfang des Rings in Berührung steht.

5. Leitschaufel-Einstelleinrichtung nach einem der Ansprüche 1 bis 4, bei der der Einstellring sowohl axial als auch in Umfangsrichtung verstellbar ist, und er über Hebel (22) mit den Leitschaufelachsen verbunden ist, um dafür zu sorgen, daß sich die Leitschaufelachsen übereinstimmend verdrehen, um die Leitschaufelposition einzustellen, wobei die Leitschaufelachsen an ersten Enden der Hebel befestigt sind und zweite Enden der Hebel mit dem Einstellring (30) verbunden sind, und das zweite Ende jedes Hebels (22) und der Ring (30) über ein erstes Element und ein zweites Element miteinander verbunden sind, wobei das erste Element entweder ein Stift (23) oder ein den Stift aufnehmendes Lager (24, 25) ist und das zweite Element das andere Teil des Stifts (23) und des Lagers (24, 25) ist, wobei das

erste Element an einem festen Ort des Hebels vorliegt, und das zweite Element an einem festen Ort des Rings vorliegt.

6. Leitschaufel-Einstelleinrichtung nach Anspruch 5, bei der das Lager ein kugelförmiges Lagerteil (24), das den Stift (23) in der Mitte verschiebbar und verdrehbar aufnimmt, und ein Gehäuse (25) aufweist, das das kugelförmige Lagerteil (24) aufnimmt.

7. Leitschaufel-Einstelleinrichtung nach einem der Ansprüche 1 bis 6, mit elastischen Teilen (26), die zwischen den zweiten Enden der Hebel (23) und dem Einstellring (30) angeordnet sind.

8. Turbokompressor mit einer Einlaßleitung (2), Leitschaufeln (3, 3a) in der Leitung zum Einstellen von Einlaßgas in den Kompressor, und mit einer Leitschaufel-Einstelleinrichtung nach einem der Ansprüche 1 bis 7, um die Positionen der Leitschaufeln einzustellen.

Revendications

1. Régulateur de pale directrice pour un certain nombre de pales (3, 3a) disposées dans un conduit de fluide (2), ayant des arbres de pales (20, 21) reliés aux pales et s'étendant radialement et espacés circonférentiellement autour du conduit, un anneau de contrôle (30) à l'extérieur et espacé de la paroi du conduit et mobile circonférentiellement et relié auxdits arbres de pales par des leviers (22) pour amener les arbres de pales à tourner en unisson pour ajuster la position des pales,
caractérisé en ce que l'anneau de contrôle (30) est supporté par des moyens de support (31, 33) agissant sur sa périphérie externe, et lesdits moyens de support sont fixés par rapport à la paroi du conduit.

2. Régulateur de pale directrice selon la revendication 1 dans lequel les moyens de support précités (31, 33) sont agencés à au moins trois emplacements séparés et espacés autour de l'anneau (30).

3. Régulateur de pale directrice selon la revendication 2, dans lequel il n'y a pas plus de six des emplacements séparés et espacés précités.

4. Régulateur de pale directrice selon la revendication 2 ou la revendication 3, dans lequel à chacun des emplacements précités les moyens de support précités comprennent un rouleau (33) contactant la périphérie externe de l'anneau.

5. Régulateur de pale directrice selon l'une quelconque des revendications 1 à 4, dans lequel l'anneau de contrôle précité est mobile axialement ainsi que circonférentiellement et est relié aux arbres de pales précités par des leviers (22) pour amener les arbres de pales à tourner en unisson pour ajuster la position des pales, dans lequel les arbres de pales sont fixés aux premières extrémités desdits leviers et les secondes extrémités desdits leviers sont reliées à l'anneau de contrôle (30), et ladite seconde extrémité de chaque levier (22) et ledit anneau (30) sont reliés par un premier élément et un second élément, ledit premier élément étant un axe (23) ou un palier (24, 25) recevant ledit axe et ledit second élément étant l'autre dit axe (23) ou du palier (24, 25), ledit premier élément étant à un emplacement fixe sur ledit levier et ledit second élément étant à un emplacement fixe sur ledit anneau.

6. Régulateur de pale directrice selon la revendication 5, dans lequel le palier précité a un élément de palier sphérique (24) recevant de façon coulissante et rotative l'axe précité (23) à son centre et un boîtier (25) retenant l'élément formant palier sphérique (24).

7. Régulateur de pale directrice selon l'une quelconque des revendications 1 à 6 comprenant un moyen élastique (26) agencé entre les secondes extrémités précitées des leviers précités (22) et l'anneau de contrôle précité (30).

8. Turbo-compresseur ayant un conduit d'entrée (2), des pales (3, 3a) dans ledit conduit pour contrôle de gaz d'entrée au compresseur, et un régulateur de pale directrice selon l'une quelconque des revendications 1 à 7 pour contrôler les positions des pales précitées.

FIG. 1

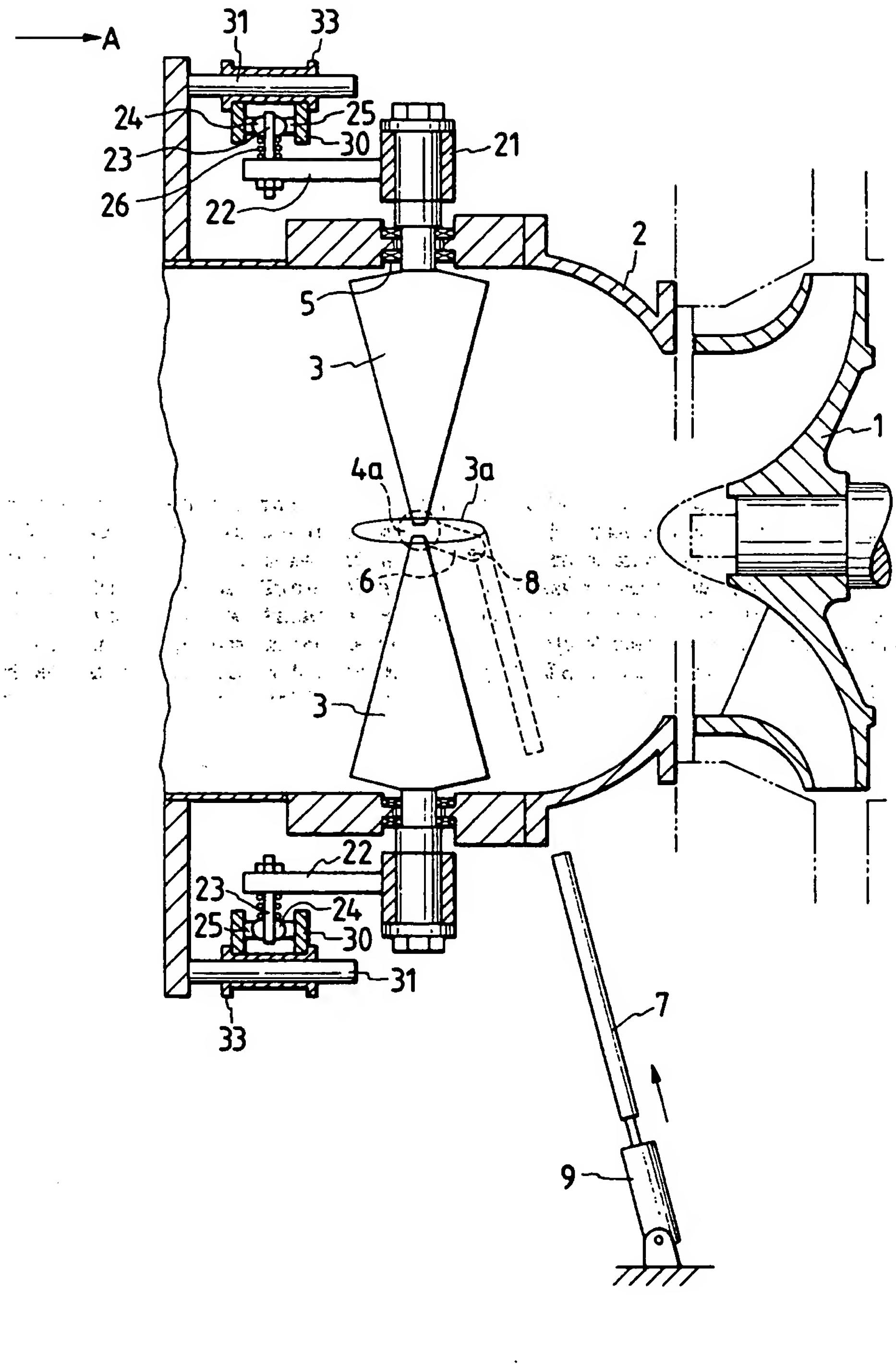

FIG. 2

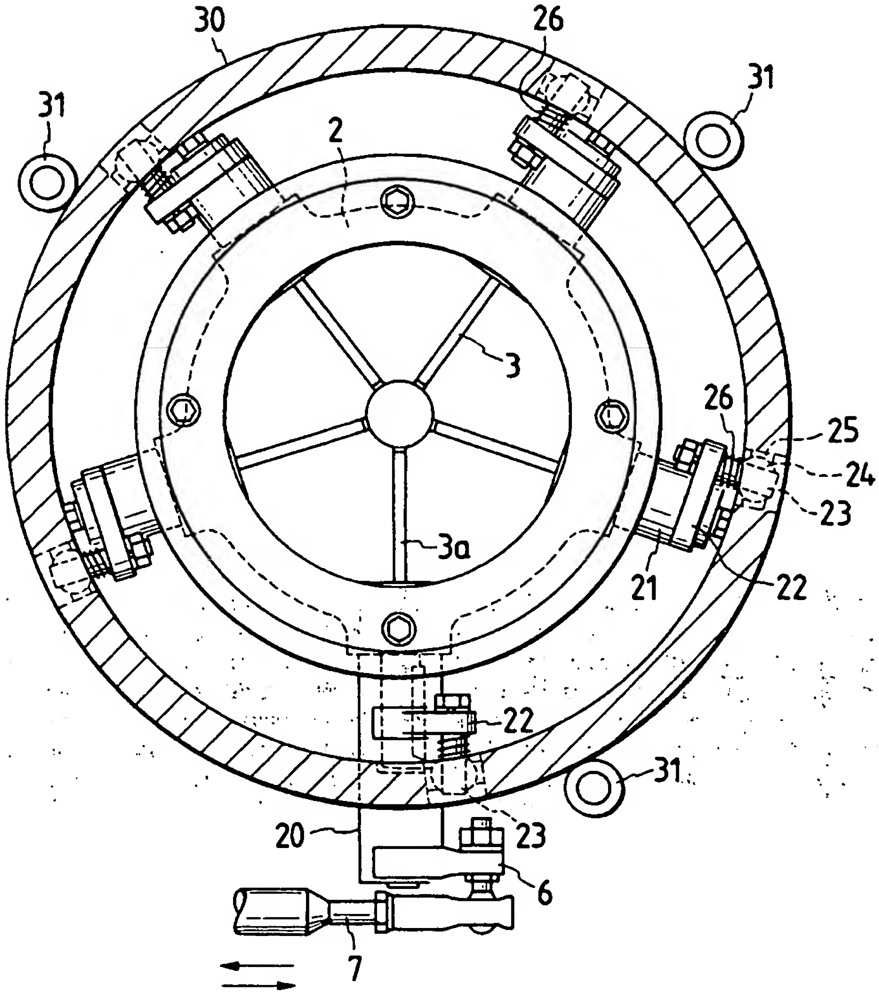

FIG. 3

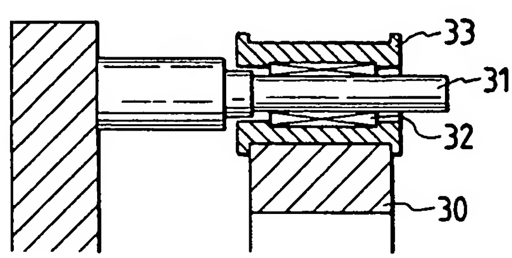

FIG. 4

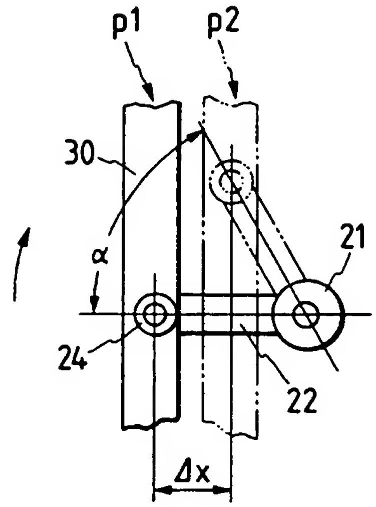

FIG. 5

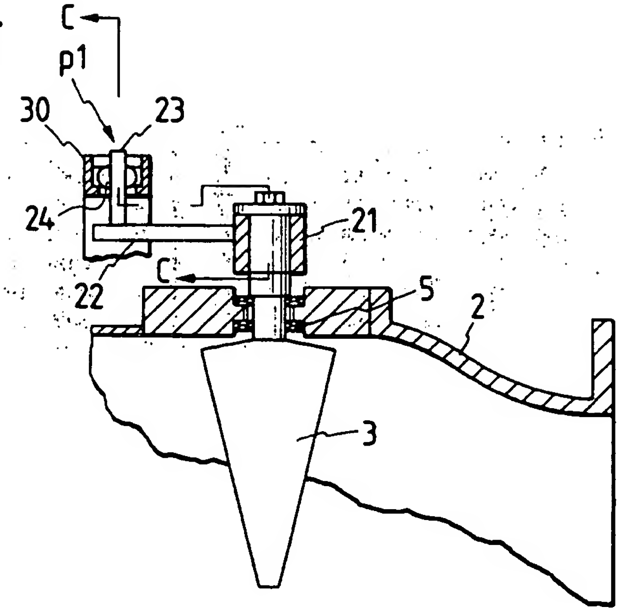

FIG. 6

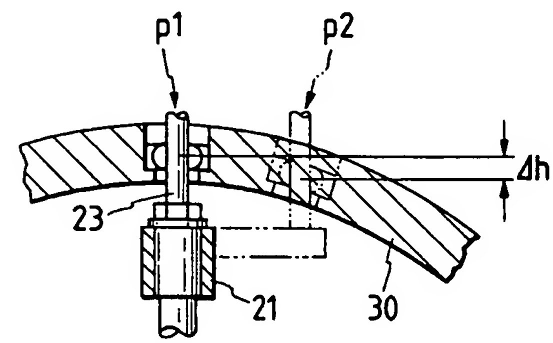

FIG. 7

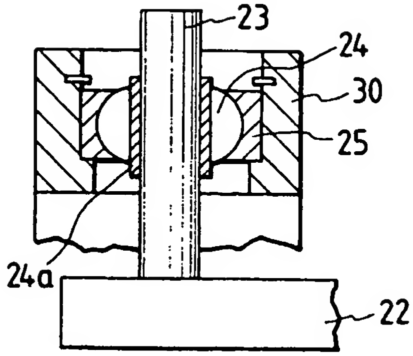

FIG. 8

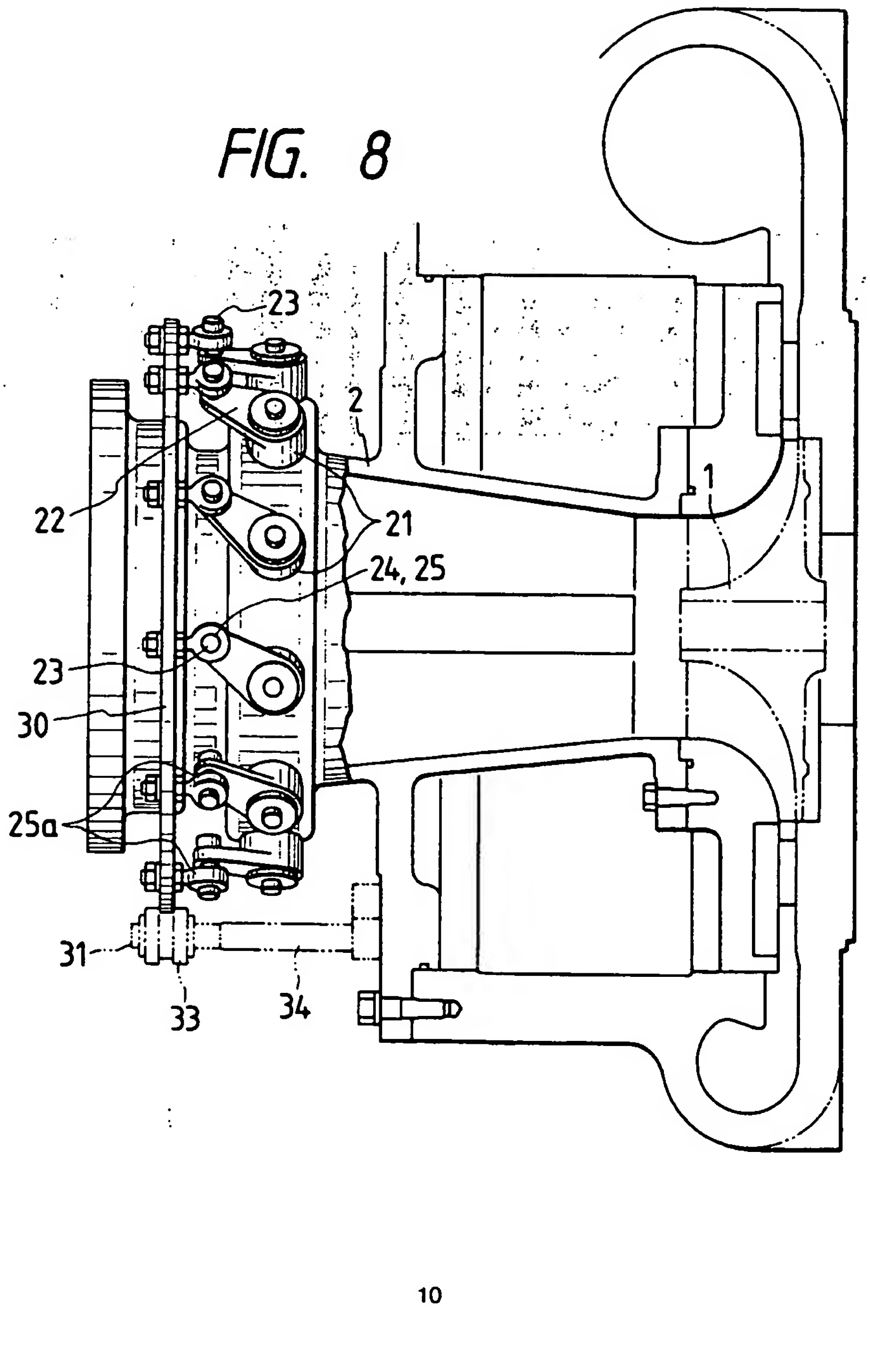

FIG. 9

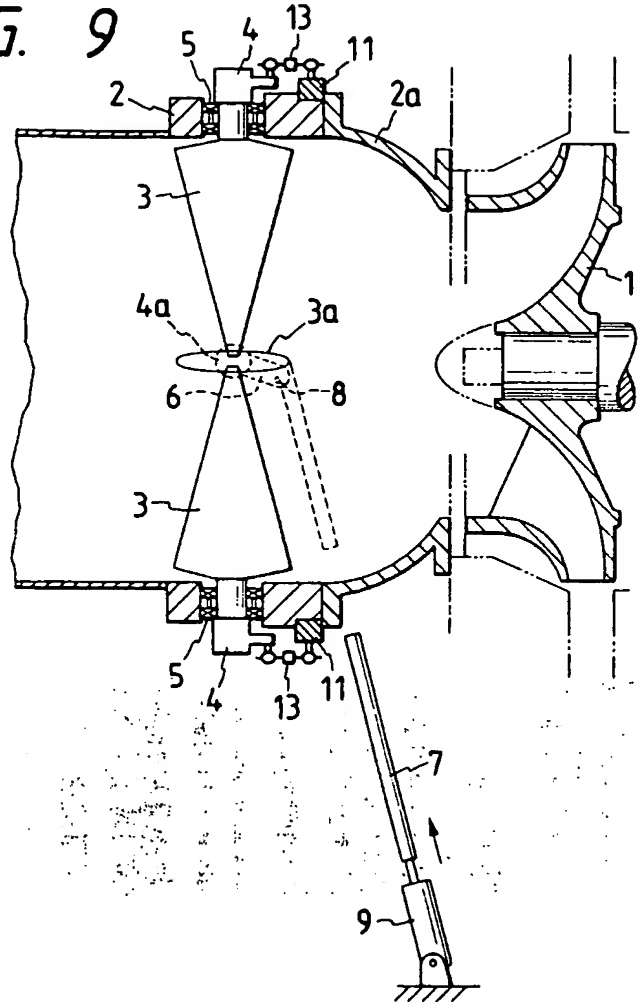

FIG. 10

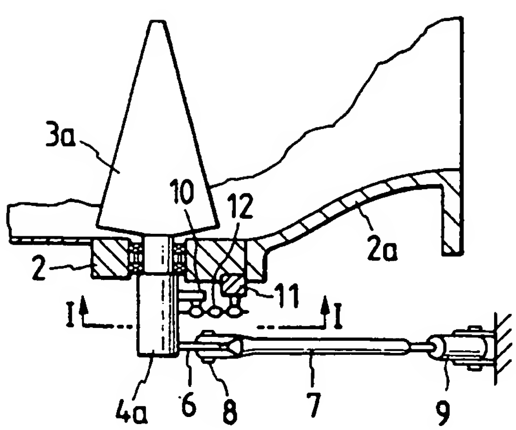

FIG. 11